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SPROUT GROWTH IN SILVER MAPLE CUT AT DIFFERENT TIMES OF THE YEAR

Report No 87-14-K

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ABSTRACT

A field study was initiated in 1983 to investigate the sprouting response of ten-year-old silver maple (Acer saccharinum L.) trees as a function of month (or season) of cutting. There was a significant effect of month of cutting on stump mortality determined in October 1986. Trees cut in the non-dormant season appeared to exhibit higher mortality than trees cut in the dormant season. The growth of sprouts was significantly smaller in trees cut in June, July and August than in trees cut in October, November and February (dormant season).

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EXECUTIVE SUMMARY

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Stump sprouting and root suckering of woody plant species on transmission line rights-of-way are a major problem to Ontario Hydro. Routine clearance work must be carried out on such lines. Any rights-of-way management program which reduces the growth of sprouts and suckers, in terms of growth in height and numbers, would be useful.

Stump sprouting is a typical response to sudden death of parent tree tops as a result of fire, cutting, or disease and physiological disorders. The capacity to produce sprouts is of tremendous importance to the survival of the woody plant. Various factors are known to influence the vigor of sprouting after decapitation. Of these, season of cutting has been reported to have a considerable influence on the vigor of sprout growth, even to the extent that cutting at certain seasons would entirely prevent sprouting.

A field study was initiated in 1983 to investigate the sprouting response of ten-year-old silver maple (Acer saccharinum L.) trees as a function of month of cutting. A group of trees was cut at intervals of one month from June 1983 to June 1984 (a new group every month) and subsequent sprout growth measured. At the evaluation in October 1986 it was found that up to 35% of the stumps in a group had died. There was a statistically significant effect of the month of cutting on stump mortality, and it would appear that trees cut in the non-dormant (or growing) season exhibited a higher mortality than trees cut in the dormant season. In those stumps that survived to October there was no obvious effect of month of cutting on the formation of stump sprouts and their persistence. Sprout growth, taken as the mean increase in height of the tallest sprout per stump from October 1984 to October 1986, was significantly smaller in trees

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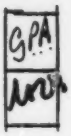
cut in June, July and August (ie. non-dormant season) than in trees cut in October, November and February (dormant season). This differential growth was exhibited in the second and/or third growing season after cutting. Such effects have been suggested to be the result of differing levels of carbohydrate reserves in the roots and stump of the parent tree, changing lengths of photoperiod, changing levels of solar radiation during sprout development and the stage of dormancy in the buds at the time of cut. Whether such differential growth effects persist over the longer term warrants further investigation.



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To Dr. D. Mills
Director of Research

SPROUT GROWTH IN SILVER MAPLE CUT AT DIFFERENT TIMES OF THE YEAR

1.0 INTRODUCTION

Stump sprouting and root suckering of woody plant species are a major problem to Ontario Hydro on transmission line rights-of-way where clearance work must be carried out periodically. Any rights-of-way management program which reduces the growth of sprouts and suckers, in terms of growth in height and numbers, would be advantageous.

Much of the information on sprout and sucker development in the literature was produced because of interest in forest products either as a source of biomass for alternative sources of energy or as a source of raw materials. Many of the reports describe the coppice method of regeneration, where trees are cut to stump height, and the sprouting of buds on the stump and roots results in fast rates of growth.

In any discussion of sprouts and suckers the terms should be carefully defined. Shoots which develop from bud on the stump are termed sprouts and shoots which develop from buds on the roots are termed suckers (Kozlowski, 1971; Kramer and Kozlowski; 1979).

Sprouting is a typical response to sudden death of parent tree tops as a result of fire, cutting, or disease and physiological disorders (Kramer and Kozlowski, 1979). The capacity of woody plants to produce sprouts is of tremendous importance to their survival. Stump sprouts which arise from dormant buds on the lower stem or root collar constitute the most important type of vegetative reproduction of hardwood forest stands.

Many of the New England hardwood forests and most of the oak forests of Pennsylvania originate from stump sprouts (Kramer and Kozlowski, 1979).

Sprouting of cut stumps may be characterized in a number of ways. The number of sprouts formed and their persistence may be of importance to Ontario Hydro in that the result of cutting could be the replacement of a single stem with many stems over a five to ten year period. The vigor of sprout growth will be important in that initial growth rates of sprouts are greater than the growth rates of seedlings of the same age (Daniel et al, 1979; Blake, 1980).

Various factors are known to influence the vigor of sprouting following decapitation. Sprouts are most readily formed on sapling-size trees, but may decline in older trees (Maini and Cayford, 1968; Stroempl, 1983). Stump height has been found to have different effects on sprouting vigor in different species (Blake and Raitanen, 1981). In some species a high stump allowed for more sprouting and in others stump height had no effect on sprouting. Season of cutting has been reported to have a considerable influence on the vigor of sprout formation (Mattoon, 1909; Brown, 1930; Roth and Hepting, 1943; Wenger, 1953; Wilson, 1968) even to the extent that cutting at certain seasons would entirely prevent sprouting (Buell, 1940). Where species exhibit a seasonal variation in vigor of sprouting, sprouting is usually maximal when trees are cut in winter and minimal when they are cut in midsummer (see Blake and Raitanen, 1981).

A study was initiated in 1983 to investigate the sprouting response of silver maple (Acer saccharinum L.) trees as a function of month of cutting. The trees, all ten years old (in 1983) were located on a single site at Wesleyville GS. Several aspects of sprouting were recorded following decapitation, including initial sprout number, sprout viability and the height of the tallest sprout after one and three years. A preliminary report (Arron, 1984) presented data collected after the first year of the experiment.

2.0 MATERIALS AND METHODS

2.1. Experimental Plant Material

The silver maple trees used in this study were located north of Lakeshore Road at the western end of Wesleyville GS. At the initiation of the experiment (June 1983) they were all ten years old, as determined by counting the annual rings on the trunk sections collected after cutting. They had been planted to replace trees removed during the construction of Wesleyville GS. Prior to starting the experiment the trees were numbered, the trunk diameters measured and the number of existing stem sprouts and root suckers (if any) recorded. At one location on

the plot, the ground was poorly drained and the trees were significantly smaller in terms of stem diameter than those at other parts of the plot. The trees in this 'wet' area were excluded from the major study, which was conducted in the 'dry' area.

2.2 Cutting

The silver maple trees to be cut were determined using a random number sequence. From June 1983 to July 1984, 35 or more trees were cut each month using a chain saw and a stump approximately 15 cm in height left. All cut material was removed from the site.

2.3 Determination of Response to Cutting

The cut stumps were examined in the fall of 1984 and 1986 for signs of regrowth. Where there were no signs of regrowth and the bark around the edge of the cut stump was beginning to weather and peel off, the stem was termed dead. In the later evaluation many of the stumps with no regrowth had begun to rot. On living stumps, all the sprouts greater than one cm in height were counted and the number of live sprouts recorded. The height of the tallest live sprout on each stump was also recorded. In a few instances, the tallest sprout found in October 1984 had died in the period up to October 1986, and the tallest remaining live sprout in 1986 was shorter than the one encountered in 1984. Rather than ascribe a negative increase in height value to such stumps, they were given a zero height increase value.

2.4 Statistical Treatment

The stump mortality in the various groups of stumps was compared using a chi-square analysis (in STSC STATGRAPHICS) with the assumption being that the time of cutting had no effect on mortality.

A Kruskal-Wallis one-way analysis of variance procedure was conducted with the data for the increase in height (from October 1984 to October 1986). The mean values for the height of the tallest sprout per stump recorded in 1986 in the secondary experiment conducted in the 'wet' area were compared using a t-test. The increase in height of the tallest sprout per stump data from this secondary experiment, for the period of October 1984 to 1986, were compared using a t-test, and were subjected to an analysis of variance and a multiple range test (Duncan).

3.0 RESULTS AND DISCUSSION

3.1 Stump Mortality

The results obtained in the two evaluations of the silver maple stumps are presented in Table 1. The number of dead stumps found at the evaluation in the fall of 1984 was very low. By the fall of 1986 a lot more dead stumps were encountered, 3 to 14 stumps per treatment group. Stump mortality from the 1986 evaluation is presented graphically in Figure 1.

In addition to plotting the number of dead stumps found for each of the monthly cuts, the number of dead stumps was expressed as a percentage of the trees in each cut to take into account the slightly different sample sizes. A chi-square analysis of the mortality data indicated that (at the $p = 0.05$ level) there was an effect of the month of cutting on subsequent stump mortality. From Figure 1 it can be seen that for trees cut during the dormant season, September through April, mortality appears to be lower than in trees cut in the growing season of May through August. The decapitation of trees severely disturbs physiological functions, which rely on photosynthesizing area, water and hormone balances. It is not surprising that tree decline and mortality may follow decapitation, however, stump sprouts may die suddenly, in the absence of disease, some time after vigorously growing sprouts have been produced (Moore, 1979; Anderson, 1979). Such was the case in the present study, where many stumps died in the second and third year following cutting, even though sprouting had been prolific immediately after the cut. The greater mortality in trees cut during the growing season, seen in the present study, may be related to the disruption of the high rate of metabolic activity in the trees. In the dormant season metabolic activity is much reduced.

3.2 Number of Sprouts Formed and Their Persistence

At the evaluation of the silver maple stumps at Wesleyville GS in October 1986 it was found that approximately 20 sprouts had been formed per stump, and that most if not all these sprouts were still alive at the evaluation (Table 1). By the October 1986 evaluation, the number of live sprouts per stump had declined, although there was no obvious relationship between the number of sprouts formed and their persistence with the month or season in which the trees were cut. Sprouts have been found to form readily on sapling-size trees, such as the silver maple at Wesleyville GS, while older (or greater stem diameter) trees are less profilic (Maini and Cayford, 1968; Stroempl, 1983; MacDonald and Powell, 1983). The decline in the number of live sprouts on the silver maple with time would be expected because of mortality resulting from competition between sprouts, or breakage by wind, snow or animals (MacDonald and Powell, 1983).

TABLE 1

Effect of Month of Cutting On Sprout Growth in Silver Maple Trees at Wesleyville GS

			Fall 1984 Evaluation					Fall 1986 Evaluation			
Portion of Plot	Date Trees Cut	Number of Trees Cut	Months from Cutting to Evaluation	Mean number of Sprouts Formed per Stump (± s.d.)	Number of Dead Trees (% Trees Cut)	Mean Number of Live Sprouts Per Live Stump (± s.d.)	Mean Height of Tallest Live Sprout Per Live Stump(± s.d.) (cm)	Months from Cutting to Evaluation	Number of Dead Trees (% Trees Cut)	Mean Number of Live Sprouts Per Live Stump (± s.d.)	Mean Height of Tallest Live Sprout Per Live Stump(± s.d.) (cm)
'Dry' Area	Jun 1983	38	16	25.9 ± 13.7	2(5)	20.9 ± 11.1	155 ± 52	40	10(26)	13.8 ± 8.0	262 ± 80
	July 1983	40	15	21.6 ± 10.9	1(3)	18.0 ± 9.0	133 ± 47	39	14(35)	14.4 ± 8.2	222 ± 84
	Aug 1983	39	14	23.1 ± 13.1	1(3)	18.7 ± 10.4	153 ± 48	38	9(23)	10.0 ± 7.9	247 ± 82
	Sep 1983	40	13	18.5 ± 9.7	0(0)	17.3 ± 8.8	165 ± 47	37	3(8)	11.5 ± 6.3	258 ± 89
	Oct 1983	37	12	21.5 ± 10.3	1(3)	20.6 ± 9.4	186 ± 40	36	7(19)	14.1 ± 7.3	313 ± 85
	Nov 1983	35	11	16.6 ± 10.6	1(3)	15.5 ± 9.2	177 ± 47	35	4(11)	9.8 ± 6.2	305 ± 102
	Dec 1983	35	10	24.8 ± 11.4	1(3)	23.2 ± 9.7	179 ± 58	34	9(26)	13.1 ± 8.1	301 ± 106
	Jan 1984	37	9	21.5 ± 10.1	0(0)	19.8 ± 10.0	180 ± 50	33	4(11)	12.7 ± 7.3	292 ± 71
	Feb 1984	38	8	21.2 ± 11.3	0(0)	20.0 ± 10.6	177 ± 57	32	8(21)	13.0 ± 6.9	309 ± 101
	Mar 1984	38	7	19.4 ± 9.9	0(0)	18.2 ± 9.9	186 ± 49	31	3(8)	12.0 ± 6.4	305 ± 74
	Apr 1984	36	6	17.0 ± 9.0	1(3)	16.6 ± 8.4	164 ± 60	30	7(19)	11.0 ± 6.4	280 ± 69
	May 1984	40	5	16.8 ± 9.1	1(3)	15.5 ± 8.6	149 ± 49	29	9(23)	9.7 ± 6.5	262 ± 89
	Jun 1984	40	4	21.4 ± 13.3	0(0)	16.6 ± 9.7	90 ± 37	28	12(30)	7.3 ± 5.4	169 ± 63
'Wet' Area	Jun 1983	14	16	16.7 ± 9.2	1(7)	15.1 ± 6.4	155 ± 36	40	1(7)	9.9 ± 5.4	230 ± 93
	Dec 1983	13	10	14.1 ± 8.2	0(0)	13.7 ± 8.0	179 ± 53	34	0(0)	10.9 ± 8.1	292 ± 106

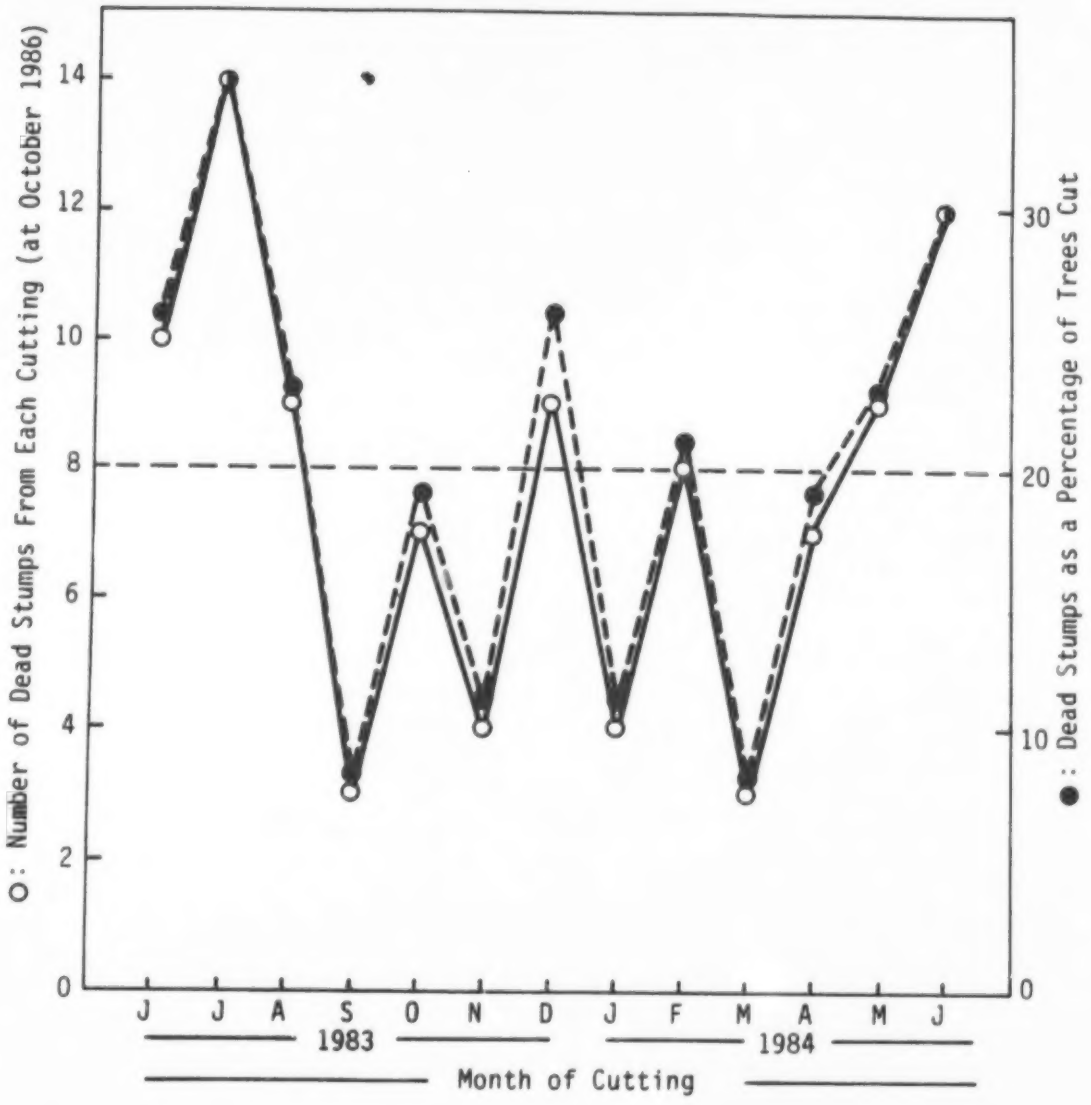

FIGURE 1

STUMP MORTALITY AS A FUNCTION OF MONTH OF CUTTING

Stumps were evaluated in October of 1986. The dashed horizontal line represents the expected percentage mortality, if month of cutting has no effect (ie total number dead stumps/total number trees cut x 100)

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Mortality in trees included in the secondary experiment in the 'wet' area was low, with only one of the twenty-seven trees in the two groups dying (Table 1).

3.3 Growth of the Tallest Sprout Per Stump

The mean heights of the tallest sprout per stump at the evaluations in October 1984 and October 1986 are presented in Table 1. In the secondary experiment conducted on the wet part of the Wesleyville site, the mean heights of the tallest sprout in October 1984 were 155 ± 36 cm and 179 ± 53 cm for trees cut in June and December of 1983 respectively, and in October 1986 were 230 ± 93 cm and 292 ± 106 cm. Comparison of such values is difficult because the age of the sprouts on the two sets of stumps will vary. Those sprouts on stumps cut in June 1983 were 16 months old at evaluation in October 1983 and those cut in December 1983 were 10 months old. Any difference in height could be due, in part, to the different ages of the sprouts. In fact the younger sprouts, ie those on stumps cut in December 1983, appear to be taller than the older sprouts at both fall evaluations (Table 1). However, a comparison of the mean values for the height of the tallest sprout at the October 1986 evaluation, when the ages of the two sets of sprouts were 40 and 34 months, revealed no significant difference in a t-test.

The fact that the sprouts on the stumps cut in different months are of different ages, poses more of a problem in the primary experiment. The ages of the sprouts range from 16 to 4 months at the October 1984 evaluation and 40 to 28 months at the October 1986 evaluation (see Table 1). In order to identify any effect that the original month of cutting had on sprout vigor the effect of age would have to be identified also. This problem is avoided by merely comparing the increase in height of the tallest sprouts per stump for the various cutting times for the 24 months from the first to the second evaluation. Such a comparison is presented in Figure 2A. Naturally only those stumps alive in October 1986 could be included in such an analysis. The data were subjected to a one way analysis of variance (Table 2a) and there were statistically significantly differences between the mean height increases for the various cutting months (at the $p = 0.05$ level). A multiple range test conducted on the data suggests that the various collections of stumps can be divided into two groups (Table 2b) with those stumps produced by cutting in October 1983, November 1983 and February 1984 being significantly different, on the basis of the growth of the tallest sprout per stump, from those cut in July and August of 1983 and June 1984. Such a distinction can be explained on the basis of the state of the tree at the time of cutting, be it in a dormant or a non-dormant state. The October, November and February group described above constitute the dormant group, whilst the non-dormant group is represented by the stumps cut in June, July and August. The

dormant versus non-dormant explanation is incomplete however, in that the remaining groups of stumps in the experiment could not be placed exclusively in either of the two categories.

The significant difference, discussed above, between the growth of sprouts on stumps produced after trees were cut in the dormant season and the growth of sprouts on stumps produced after trees were cut in the non-dormant season, is of particular interest because it appears that season of cutting has a long-term effect on subsequent sprout growth. The increase in height of the tallest sprout per stump data were for the 24 month period October 1984 to October 1986, a period that started from 16 to 4 months after the trees were cut. Thus those trees cut in July and August of 1983, were left to sprout for 15 and 14 months respectively, before initial height measurements were taken in October 1984. Since both these groups of stumps were found to be in the low growth group (non-dormant) after the multiple range test (see Table 2b), the deleterious effects of cutting on sprout growth were exhibited in the 1985 and/or the 1986 growing seasons. It would appear that cutting in July or August resulted in long-term damage to the stump and root system. Poor sprout growth in the second and/or third year after cutting in the non-dormant season may be the inevitable result of poor growth in the previous year. Poor first or second year growth might lead to inadequate replenishment of carbohydrate reserves in the root system which results in continued poor growth in the subsequent year. Such a cycle of poor growth might be perpetuated for several years.

From a purely subjective point of view, it is worth noting that the shape of the three curves of sprout growth in Figure 2 is remarkably consistent. The shape of the 1984 evaluation curve is reproduced in the 1986 evaluation curve (both curves - see Figure 2B), with if anything, differences between the high and low points being made more obvious. The increase in height curve for the 24 months October 1984 to 1986 (Figure 2A) has a similar appearance to both evaluation curves.

When the increases in height of the tallest sprout per stump for the 24 months from October 1984 for the silver maple stumps in the 'wet' area of the Wesleyville GS plot were compared in a t-test, there was no significant difference between the growth of sprouts on stumps cut in June 1983 and those on stumps cut in December 1983 (data from Table 1). Only thirteen trees were included in each of the two treatments (one stump cut in June 1983 had died by October 1984) which was considerably fewer than were included in the major experiment described above. Although silver maple develops best in well-drained, moist soils (Fowells, 1965), it is extremely tolerant of flooding (Hosner,

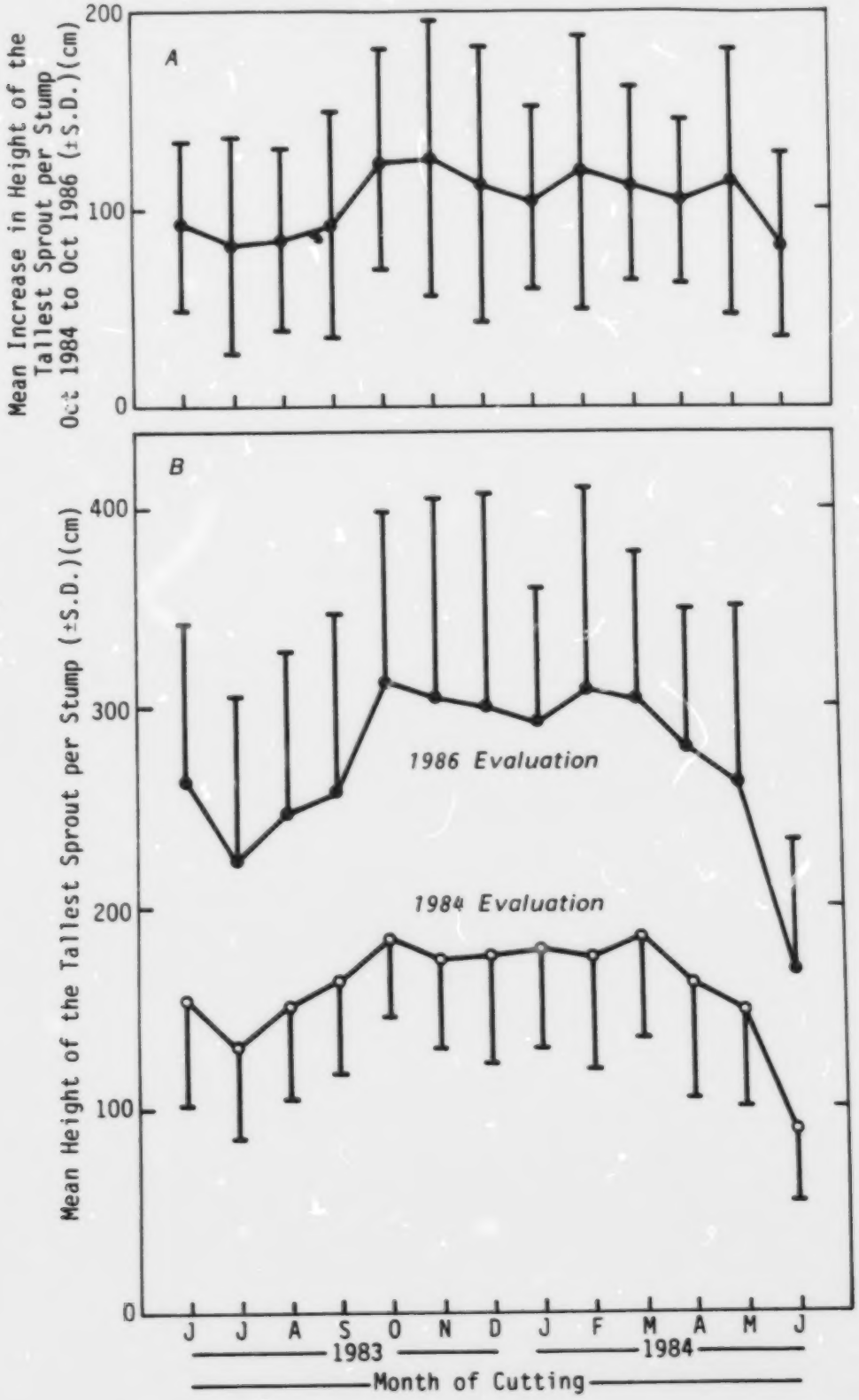


FIGURE 2

GROWTH OF THE TALLEST SPROUT PER STUMP AS A FUNCTION OF MONTH OF CUTTING

A: Increase in height of the tallest sprout per stump from October 1984 to October 1986 (only stumps alive in 1986 included)

B: Height of the tallest sprout per stump at October 1984 and October 1986

TABLE 2

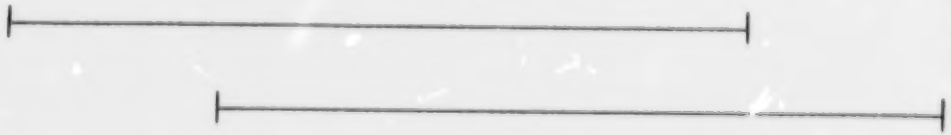
a) Effect of Month of Cutting On The Growth of the Tallest Sprout Per Live Stump from October 1984 to October 1986

Date Trees Cut	Mean Increase in Height of the Tallest Sprout Per Live Stump (cm)	Standard Deviation	Number of Live Stumps*	Source of Variation	One-Way Analysis of Variance				
					D.F.	S.S.	M.S.	F. Value	Pr > F
Jun 1983	92.6	43.1	28	Between treatments	12	87343	7279	2.33	0.0068
July 1983	81.5	54.0	26	Within treatments	381	1188108	3118		
Aug 1983	83.8	46.2	30	Total	393	1275451			
Sep 1983	92.1	56.1	37						
Oct 1983	122.5	54.0	30						
Nov 1983	125.9	70.7	31						
Dec 1983	112.7	71.1	26						
Jan 1984	103.9	44.1	33						
Feb 1984	118.3	70.5	30						
Mar 1984	111.9	49.0	35						
Apr 1984	103.9	42.9	29						
May 1984	112.8	66.9	31						
Jun 1984	80.6	45.2	28						

*Only stumps alive in 1986 were included in the data set. Some stumps died in the period October 1984 to October 1986.

b) Multiple Range Test Comparing Mean Increase in Height of the Tallest Sprout Per Stump with the Month in Which the Parent Tree Was Cut.

Month of Cutting	Nov'83	Oct'83	Feb'84	May'84	Dec'83	Mar'84	Apr'84	Jan'84	Jun'83	Sept'83	Aug'83	Jul'83	Jun'84
Mean increase in height of the tallest sprout	125.9	122.5	118.3	112.8	112.7	111.9	103.9	103.9	92.6	92.1	83.8	81.5	80.6



Mean increases in height which do not differ significantly have been underlined by the same bar, the significance level being 5%. Those mean increases in height which differ significantly are underlined by different bars.

1960; Teskey and Hinckley, 1977b). As described in the Materials and Methods, the silver maple trees in the 'wet' area of the plot were excluded from the major study because their stems were significantly smaller in diameter than those at other parts of the plot. Sprout growth observed during the course of the experiment appeared to be the same on stumps in the 'wet' and 'dry' areas (compare a mean height of the tallest sprout per stump after 34 months of 292 ± 106 cm for trees in the 'wet' area with a value of 301 ± 106 cm for trees in the 'dry' area - both groups cut in December 1983, see Table 1). Dormant season flooding is not deleterious to deciduous trees (Teskey and Hinckley, 1977a), only floods that occur after budbreak affect silver maple growth. Peterson and Bazzaz (1984) reported that silver maple seedlings that had previously experienced flooding (as had the trees in the 'wet' area at Wesleyville GS) had a greater capacity for recovery of preflood photosynthetic and transpiration rates than seedlings inundated for the first time.

3.4 Relationship Between Stump Survival and the Mean Increase in Height of the Tallest Sprout per Stump from October 1984 to October 1986

As discussed in the previous three sections, both stump mortality and the growth of the tallest sprout per stump appear to be related to the season, be it dormant or non-dormant, in which the silver maple trees were cut. When stump survival, the converse of mortality, is plotted against the mean increase in height of the tallest sprout per stump from October 1984 to October 1986, the effect of season of cutting is revealed once more. Stumps of trees cut in the growing or non-dormant season appear to exhibit a lower survival rate and a lower growth rate than stumps of trees cut in the dormant season (Figure 3). The non-dormant season stumps appear to be clustered on the left of the graph, while those cut in the dormant season are clustered higher and to the right of the non-dormant group. Those two points on the graph, numbered 4 and 12, which were classified as non-dormant cuttings, were not placed within the non-dormant cluster on the graph. Both these cuttings, in September 1983 and May 1984, were made at the interface of the dormant/non-dormant seasons. While budbreak occurs in May, there will be little sprout growth, as is the case in September, the very end of the growing season when temperatures drop and photoperiod is reduced.

Previous work by MacDonald and Powell (1985) described how the rate of elongation of stump sprouts decreased with each successive date of cut (dormant period through August 10th) in sugar maple (Acer saccharum Marsh), but was similar for all dates of cut in red maple (A. rubrum L.) (Wilson, 1968).

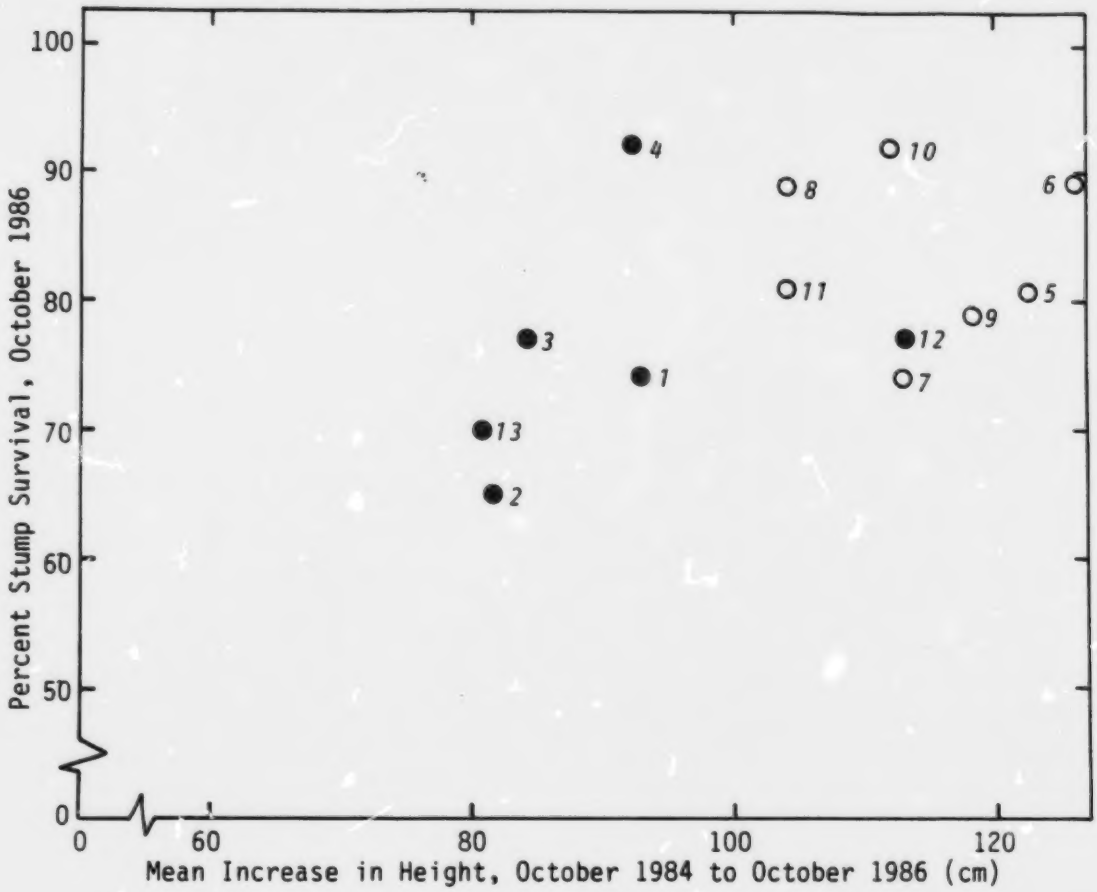


FIGURE 3

PLOT OF STUMP SURVIVAL AGAINST THE MEAN INCREASE IN HEIGHT FROM OCTOBER 1984 TO OCTOBER 1986 OF THE TALLEST SPROUT PER STUMP

Key:

1	*June 1983 cutting**	8	*January 1984 cutting*
2	*July 1983 cutting**	9	*February 1984 cutting*
3	*August 1983 cutting**	10	*March 1984 cutting*
4	*September 1983 cutting**	11	*April 1984 cutting*
5	*October 1983 cutting*	12	*May 1984 cutting**
6	*November 1983 cutting*	13	*June 1984 cutting**
7	*December 1983 cutting*		

Cuttings marked with an asterisk (and as closed circles in the figure) occurred during the non-dormant season, the remainder (open circles in figure) occurred during the dormant season.

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MacDonald and Powell (1985) also found that adventitious roots developed only on sprouts arising after the dormant season cut. These sprouts attained a degree of independence from the parent stump and increased survival chances in the first growing season as compared with sprouts arising after non-dormant season cuts. Survival of stumps of silver maple in the present study appeared to be greater in trees cut in the dormant season. MacDonald and Powell (1985) reported that in sugar maple, the internodes on sprouts arising after the dormant season cut appeared frost hardy by late October, whereas the proportion of frost-hardy internodes on sprouts arising after non-dormant season cuts decreased with each successive date of cut. Similarly, Mattoon (1909) described American chestnut (Castanea dentata Borkh.) sprouts arising after dormant season cuts as frost hardy by December and those arising after May cuts as having imperfectly lignified upper portions. Further he reported that the upper 30 to 50% of these latter sprouts were winter killed.

Different dates of cut represent interventions at different times in the annual cycle of tree growth and development. Although several workers have related differences in sprout growth to carbohydrate reserve levels in roots of parent trees on the date of cut (Aldous, 1929; Roth and Hepting, 1943; Clark and Liming, 1953), Wenger (1953) found that sprout growth and carbohydrate concentration were not well correlated. MacDonald and Powell (1985) suggest that carbohydrate reserve levels in roots and stumps of parent trees, changing lengths of photoperiod, changing levels of solar radiation during sprout development, and depth of rest (sensu Romberger, 1963) in dormant buds, at the time of cut, all influence sprout development. Sprout growth following a dormant-season cut is supported by medium levels of reserve carbohydrates (Wargo, 1971, 1979) and occurs, in part, under increasing photoperiods and increasing levels of solar radiation. Low levels of reserve carbohydrates shortly after bud break (Wargo, 1971, 1979) from mid-May to mid-June would restrict initial sprout growth. After late June and July cuts, decreasing photoperiod and decreasing levels of solar radiation result in reduced sprout growth despite medium levels of reserve carbohydrates (Wargo, 1971, 1979). After August cuts, rest is being or has been induced in dormant buds. Reduced sprout growth in a growing season would lead to an inadequate replenishment of carbohydrate reserves in the root system, this could then result in poor sprout growth in the subsequent growing season.

4.0 CONCLUSIONS

1. At the first evaluation, in October 1984, few of the silver maple stumps had died. By October 1986 up to 35%

of the stumps in a monthly cutting group had died. There was a statistically significant effect of the month of cutting on stump mortality. Mortality in trees cut in the non-dormant season appeared to be higher than in trees cut in the dormant season.

2. There appeared to be no effect of month of cutting on the formation of stump sprouts and their persistence for the two to three years following the cut, in those stumps that survived to October 1986.

3. The growth, taken as the mean increase in height of the tallest sprout per stump, of the sprouts was significantly smaller in trees cut in June, July and August (the non-dormant season) than in trees cut in October, November and February (the dormant season). This differential growth was exhibited in the second and/or third growing season after cutting. Such effects have been suggested to be the result of differing levels of carbohydrate reserves in the roots and stump of the parent tree, changing lengths of photoperiod, changing levels of solar radiation during sprout development and the depth of rest in the dormant buds at the time of cut. It appears that poor sprout growth in a growing season may be followed by poor growth in the following season, although this requires further investigation.

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